2.1.9. AIRCRAFT PROJECT

The aircraft project was started in 1992 to measure CO_2, CH_4, and CO gradients, and seasonal cycles from the boundary layer to the mid-troposphere. By sampling the free troposphere, mid-continent trace gas values can be measured without being affected by localized sources and sinks. These values can then be used to limit the number of regional source-sink scenarios that need to be considered in inverse-modeling studies. In addition, if the CO_2 values are measured often enough, a seasonal cycle can be constructed. The seasonal cycle variation with altitude indicates the rate at which mixing ratio changes propagate upwards. This vertical mixing rate information can also help constrain the models by better defining atmospheric circulation.

In 1993, vertical profiles of CO_2, CH_4, and CO were sampled at least every 2 weeks over Carr, Colorado (40.9°N, 104.8°W), using a previously-developed automated sampling system in a light, single engine aircraft (Cessna T-182). The profiles consist of 20 samples each, generally taken mid-morning between about 2 and 6 km above sea level (which is about 0.5 to 4.5 km above ground level at Carr). Winds below the boundary layer are usually from the south at less than 5 m s^{-1}, and winds above the boundary layer are usually from the north or west at more than 10 m s^{-1}. Figure 2.16 shows the results from a typical flight. Where sample pairs were taken at a given altitude to test pair agreement, the line plots the average of the pair values. All three trace gases show decreasing mixing ratios with increased height since there are anthropogenic sources but few sinks at ground level during the winter. The increase in mixing ratios for all three gases between about 3.0 and 5.5 km, and particularly the well-correlated increase at 4 km, may indicate an urban-polluted air mass that has been transported to the sampling site. Trajectory analysis from the previous year during this season suggests that the air aloft is transported from the west and crosses the California The coast anywhere between San Francisco and the Mexican border. Although profiles over Carr are often interrupted by these polluted air masses, the gradients and seasonal trends remain consistent over multiple flights.

Sampling at the Carr site began in November 1992, so with over a year of data available at the end of 1993, a seasonal cycle can be estimated for any given altitude range. Figure 2.17 shows the CO_2 data for 1993 in a 1-km wide band centered at 3 km above sea level. The overlaid curve is the sum of the first two harmonics of the fitted seasonal cycle using the same fitting techniques as are used for network flask data.

Figure 2.18 shows seasonal cycle plots for 1-km wide bands centered at 3-, 4-, 5-, and 6-km above sea level. The plot shows two significant features. The first is a decrease in seasonal cycle amplitude of about 0.6 ppm between the 3- and 6-km bands that gives a consistent picture of decreasing source-sink effects with increasing altitude. The second feature is a delay of about 6 weeks in the onset of spring draw-down between the lowest and highest altitudes. This information can be used to help constrain the vertical mixing rate of the troposphere in this region as an additional constraint for global circulation models.

In addition to data collection, work continued on sampling methods in 1993. A new version of the automated sampling system was developed using two-valve flasks that may be flushed with sample air before filling. The previous design had only one valve per flask and relied on evacuating the flask before sampling, a process that was subject to contamination and leaks. Also in 1993, attempts were made to use

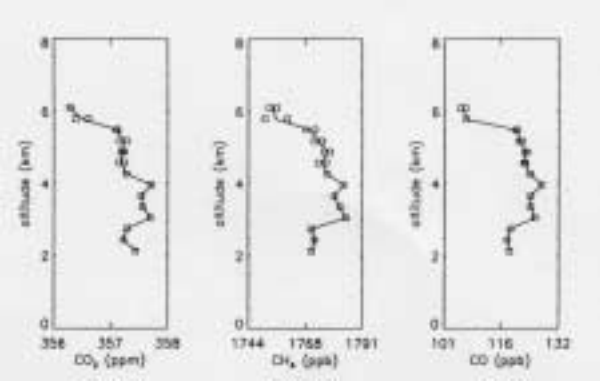

Fig. 2.16. Typical profiles of CO_2, CH_4, and CO versus height (km) over Carr, Colorado, December 14, 1993.

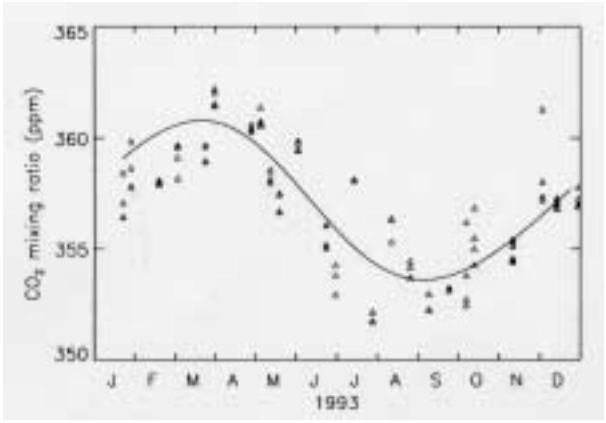

Fig. 2.17. CO_2 seasonal cycle at 3-km height over Carr, Colorado, for 1993.

different models of light aircraft (Cessna T-210) to reach higher into the troposphere, up to 8.5 km above sea level. Early efforts were plagued by contamination from the plane engine exhaust, but this work will continue. The first version of the sampling system was also flown in a Russian AN26 aircraft over Bennett Island (150°E, 76°N) in an attempt to measure possible local CH_4 emissions. Although the sampling system performed well overall, a leak in the pump head contaminated the results. The visit to Russia was also used to lay the groundwork for a 2-yr biweekly sampling program over Yakutsk (129°E, 62°N) to begin in 1994.

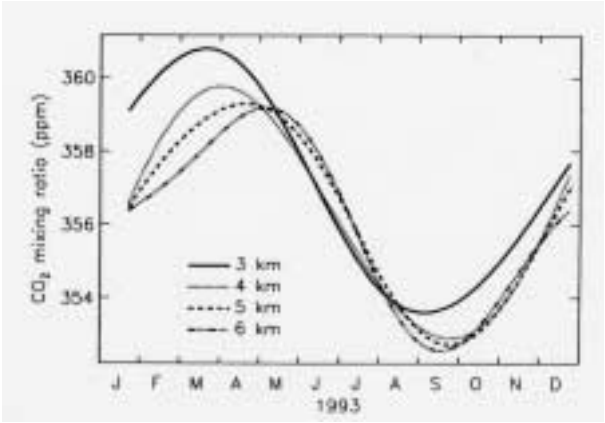

Fig. 2.18. CO_2 seasonal cycle at 3-, 4-, 5-, and 6-km height over Carr, Colorado, for 1993.